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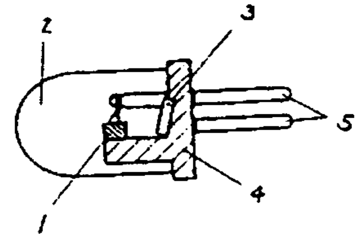

APPLICANT : MATSUSHITA ELECTRIC IND CO LTD;

INVENTOR : WADA MASARU;

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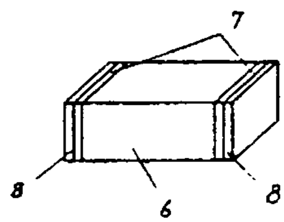
TITLE : SEMICONDUCTOR LASER DEVICE



ABSTRACT : PURPOSE: To enable the manufacture of a device at a low cost by a method wherein a silicon film whose thickness is 7/100~8/100 of a wavelength is coated on an aluminum film coated on an end face whose thickness corresponds to one-fourth of a wavelength, which are sealed with a transparent plastic resin of a refractive index of 1.3~1.6.

CONSTITUTION: A semiconductor laser element 1 and a photodiode 3 are buried in a transparent plastic resin 2 in place of a cap provided with a window glass. In this process, an aluminum film 7 1/4 as thick as a wavelength and a silicon film 8 7/100~8/100 as thick as a wavelength are laminated on both the end faces of the passivation film of the laser element 1, whereby the refrectivity of both the end faces decreases to about 32% when the element 1 is buried in the resin of a refractive index of 1.3~1.6. Therefore, a laser oscillating threshold current and a differential quantum efficiency of the element 1 are made equal to those of a conventional element, so that the element 1 does not vary in characteristic. By these processes, a package can be decreased in cost, a divergence angle can be controlled, and the element is also excellent in heat dissipation and hermetic sealing.

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TUC3 Room temperature continuous wave vertical cavity surface emitting GaAs injection lasers

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K. TAI, R. J. FISCHER, C. W. SEABURY, N. A. OLSSON, T. D. C. HUO, Y. OTA, A. Y. CHO, AT&T Bell Laboratories, Murray Hill, NJ 07974.

There has been a surge of interest in vertical cavity surface emitting laser diodes (VCSELs).[1-4] The ability of room temperature cw operation is crucial to the practical use of such devices. We report room temperature cw operation of GaAs VCSELs. The VCSEL shown in Fig. 1 was grown by molecular beam epitaxy and, starting from the Si doped GaAs substrate, consisted of an *n*-type $Al_{0.3}Ga_{0.7}As$ etch stop followed by an *n*-type twenty-two-pair $Al_{0.1}Ga_{0.9}As/AlAs$ semiconductor distributed Bragg reflector (DBR), an $Al_{0.3}Ga_{0.7}As/GaAs$ (0.5-μm) double heterostructure active region, a five-pair *p*-type $Al_{0.1}Ga_{0.9}As/Al_{0.7}Ga_{0.3}As$ semiconductor DBR, a 450-Å $Al_{0.7}Ga_{0.3}As$ phase matching layer, and finally a 100-Å GaAs heavily *p*-doped contact layer.

The *p*-mirror termed hybrid metal DBR here uses constructive interference between the reflection from a five-pair semiconductor DBR and metal layer. The room temperature lasing threshold occurred at 40 mA dc (22-kA/cm^2 current density neglecting the lateral current spreading). An optical power in excess of 1 mW was measured. The external slope quantum efficiency was ~2%. The emission spectrum below the threshold showed a broad structure (reflecting the broad gain spectrum) with the superimposition of an ~4–5-Å sharp spike due to the cavity resonance enhanced emission. Above the threshold, the width of the cavity mode reduced to 1 Å (spectrometer resolution-limited), and its intensity dominated. The usual exponential temperature dependence of threshold current [$I_{th} \sim \exp(-T/T_0)$] was measured for the VCSEL, and T_0 was found to be 115 K in the temperature range of 15–50°C. The emission of the VCSEL was found to be omnidirectional below the threshold. An abrupt change in the far field pattern occurred at the threshold, where a symmetric 2-D Gaussianlike profile appeared with an emission (full) angle of ~5°.

Figure 2 shows the results (part of the bit pattern and an eye diagram) of a pseudorandom signal modulation of the VCSEL at a 500-Mbit/s data rate. The optical spectrum of the random signal VCSEL emission was essentially the same as that of the cw emission with a more than 25-dB side-mode suppression ratio measured with a 1-Å resolution.

Summarizing: Room temperature cw single-longitudinal and single-transverse-mode vertical cavity surface emitting lasers were constructed with an emission power >1 mW.

1. T. Sakaguchi, F. Koyama, and K. Iga, Electron. Lett. **24**, 928 (1988).
2. L. M. Zinkiewicz *et al.*, Appl. Phys. Lett. **20**, 1959 (1989).
3. F. Koyama, S. Kinoshita, and K. Iga, in *Technical Digest, Conference on Lasers and Electro-Optics* (Optical Society of America, Washington, DC, 1989), paper FC1.
4. A. Ibaraki *et al.*, in *Technical Digest, Seventh International Conference on Integrated Optics and Optical Fiber Communication*, Kobe, Japan (1989), paper 18B1-3.

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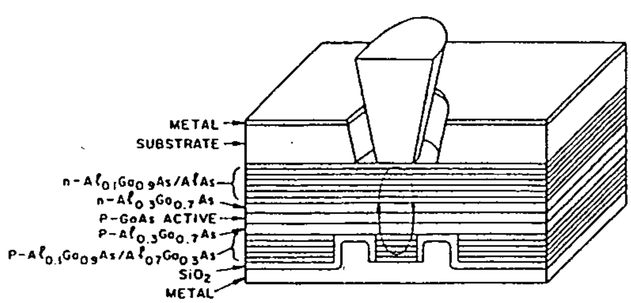
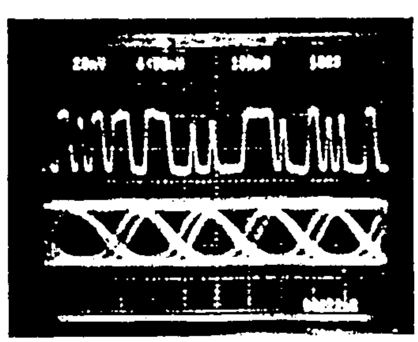


TUC3 Fig. 1. Cross-sectional representation of the VCSEL consisting of the substrate an *n*-type twenty-two pair DBR reflector, a $GaAs/Al_{0.3}Ga_{0.7}As$ double heterostructure active region, and a hybrid *p*-type metal DBR reflector.



TUC3 Fig. 2. Eye diagram (bottom) and random data stream (top) at 500 Mbit/s.